its sternum—all died. The average oscillation of variation around an ideal mean was also shown to be almost invariably in excess for the birds which perished, and the conclusions arrived at were as follows:

The birds which perished were not simply accidental sufferers from the severity of the storm, but were birds which were physically disqualified for enduring the intensity of the New England climate, as expressed by the storm of February 1st, and they were consequently eliminated by natural agents. The result of this elimination produced in this particular locality a colony of birds measurably different from those existing before the storm, that is, the action of natural selection resulted in the elimination of the unfit and the survival of the fit.

On the Anatomy of the Spermatozoon of Invertebrates. G. W. FIELD. (With demonstration of the apical body.)

THE widest diversity in the form of the spermatozoon is found among the different groups of the invertebrated animals. Closer examination shows that there is, however, one type of form which obtains in by far the greater majority of species, and that the aberrant forms are peculiar to those species which have either become parasitic, *e. g.*, certain worms and arthropods, or which have acquired specially modified secondary sexual organs, *e. g.*, lobster, crayfish, *Limulus.*

The common type is the familiar tailed form, prevalent one in the groups Cœlenterata, Vermes, Echinoderma, Mollusca, Arthropoda and Tunicata. The three general divisions are usually distinct and readily recognizable Rarely the spermatozoa of all the species studied have a special structure or apical body at the anterior tip of the head. It has been variously described as (1) an adaptation for boring into the egg; (2) a remnant of the cytoplasm; (3) fluid expressed from the nucleus upon shrivelling; (4) a micropore surrounded by 'Ringkörper;' (5) an apical button present in the unripe spermatozoon; (6) the sperm centrosome. The first five opinions seem to have little importance when considered in connection with the origin of this apical body. While the opinion of myself and others that it is the sperm centrosome is refuted by the weight of evidence that the sperm centrosome comes from the middle piece of the spermatozoon, yet, so far as I know, the function of this apical body has not been noted by any of those who have studied so successfully the fertilization process. Since it has the same microchemical reactions and the same origin as as the middle piece, it would appear as if its fate must be of considerable consequence. I have found this apical body in more than forty species, representing all the groups from the Cœlenterates to Amphioxus (including Toxopneustes). By others it has been found in upwards of twenty additional species.

The fact that the apical body is present in the spermatozoon of well-nigh every species studied indicates that it has some very special significance which should not be overlooked by workers on the phenomena of fertilization.

The Middle Piece of the Urodele Spermatozoön. J. H. MCGREGOR. (Read by title.)

The Origin of the Yolk in the Egg of Molgula. HENRY E. CRAMPTON, JR.

THE author presented the principal results of an extended study upon the early history of the ascidian oöcyte, considered from a chemical as well as from a purely morphological aspect, made by means of carefully controlled aniline staining supported by artificial digestion and other tests. It was found that the cell-body at the beginning of enlargement of the primary oöcyte presents no albumen reaction. There is, however, a small albuminous gran-

ular body formed just outside the nucleus, which enlarges by the addition of granules similar to those found in the nucleus, until it becomes first a cap-shaped mass and finally surrounds the nucleus. *1st Period: Formation of the 'yolk-mass.'* This body then disintegrates, the constituent granules being spread evenly throughout the now highly vacuolated cell-body. The latter was shown to be composed probably of a pseudo-nuclein. *2d Period: Disintegration of the yolk-mass.* The ovum assumes its final character by the progressive vacuolization of the cell-body, and by the enlargement of the products of disintegration of the 'yolk-mass' to form the definite 'deutoplasm' spheres. *3d Period:* The original was considered to be of nuclear origin, and is probably what has been loosely homologized in some cases with the 'corps vitellin de Balbiani,' etc.

Protoplasmic Movement as a Factor of Differentiation. EDWIN G. CONKLIN.

VARIOUS factors have been suggested by different persons as the causes of differentiation, but so far no one has shown that the active movements of protoplasm constitute such a factor.

The polarity of the egg and the specializations of cleavage are two of the earliest differentiations of the developing organism. In the gasteropod *Crepidula* both of these differentiations are associated with definite and orderly movements of the protoplasm.

Before the maturation the germinal vesicle lies near the center of the egg and the yolk is uniformly distributed. With the appearance of the centrosomes and the formation of the first maturation spindle the nuclear membrane is broken opposite the poles of the spindle, nuclear sap escapes into the cell and at the same time the nucleus, spindle and surrounding cytoplasm are carried bodily toward the surface of the egg. Coincidently with this migration of the nuclear constituents there is a segregation of the cytoplasm at one pole (the animal) and of yolk at the other (the vegetal). This separation of yolk and cytoplasm goes on during the second maturation division and throughout all the stages of fertilization. The movements of the germinal vesicle and of the maturation spindles, the separation of yolk and cytoplasm and also the approach of the pronuclei during fertilization seem to be due to protoplasmic currents.

In the cleavage of the egg the evidence for such currents is much more abundant and complete. Centrosomes and *Zwischenkörpern* are preserved throughout the resting period following division, and by means of the relative positions of these bodies at different stages, as well as the relative positions of the nuclei, yolk and cytoplasm, the direction and extent of these movements can be accurately determined. During the anaphase of the first cleavage the spindle lies at right angles to the egg axis, and the centrosomes, chromatic plates and *Zwischenkörper* are in a straight line. In later stages the *Zwischenkörper* is carried down to the center of the egg, the centrosomes are carried up to the surface and move toward each other until they come to lie on each side of the first cleavage plane and immediately under the polar bodies; the nuclei are also moved upward and toward each other until they are almost in contact on opposite sides of the first cleavage wall, and the cytoplasm moves down into the center of the egg, the yolk at the same time moving up at the periphery. Such movements could be caused only by vortical currents in the daughter cells moving up at the surface and down through the center of the egg; the cell wall forms where these opposite currents meet.

Similar vortical currents occur in every cleavage up to a late stage, and they offer most important evidence not only as to the mechanics of cleavage, but also as to the me-